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(54) A brake pressure regulator for an hydraulic vehicle braking system

(57) In a housing (10), a stepped piston (40) bounds an inlet chamber (20) with its smaller face (A36) and an outlet chamber (24) with its larger face (A38). These two chambers (20, 24) are connected to each other by a valve (44, 46) which is controlled by the stepped piston (40). The inlet chamber (20) is also bounded by an auxiliary piston (30). Between the two pistons (30, 40), a spring (54) is arranged which tends to hold the stepped piston (40) at a first stop (52) against the pressure in the outlet chamber (24) and to hold the auxiliary piston (30) at a second stop (56) against the pressure in the inlet chamber (20). The difference between the faces (A38—A36) of the stepped piston (40) is greater than the operative face (A30—A36) of the auxiliary piston (30) on the inlet side. Movement of the auxiliary piston (30) in the direction of the outlet chamber (24) is limited by a third stop (58) formed on the housing (10), said stop not interfering with the freedom of movement of the stepped piston (40). The brake pressure regulator, which is preferably connected in series to one or more rear-wheel brakes, thus takes on a regulating characteristic which closely conforms to the ideal, almost parabolic curve of pressure in the rear-wheel brakes in relation to the pressure in the front-wheel brakes.

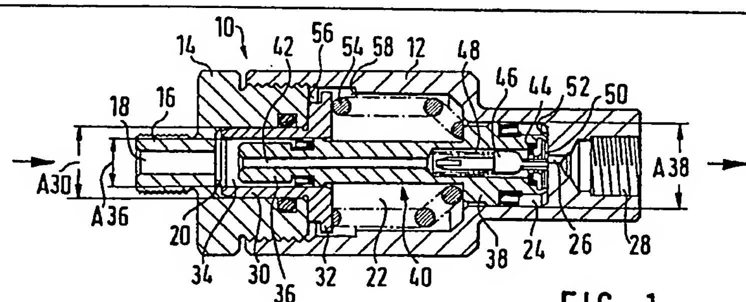
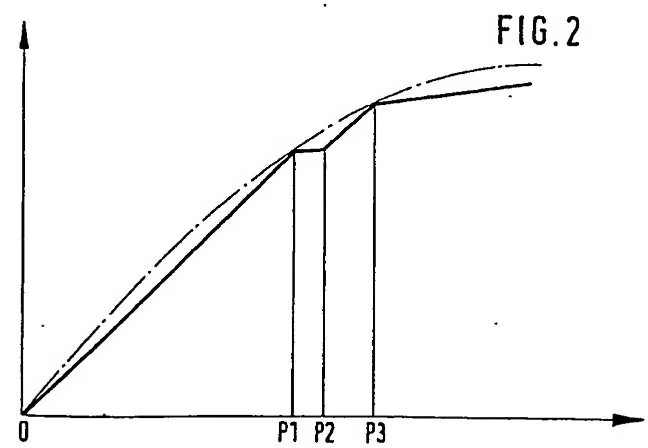


FIG. 1

FIG.2


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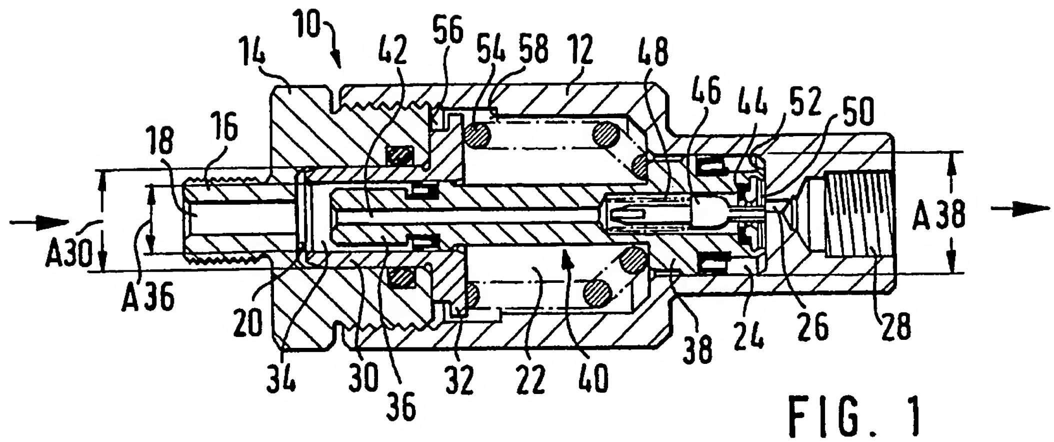
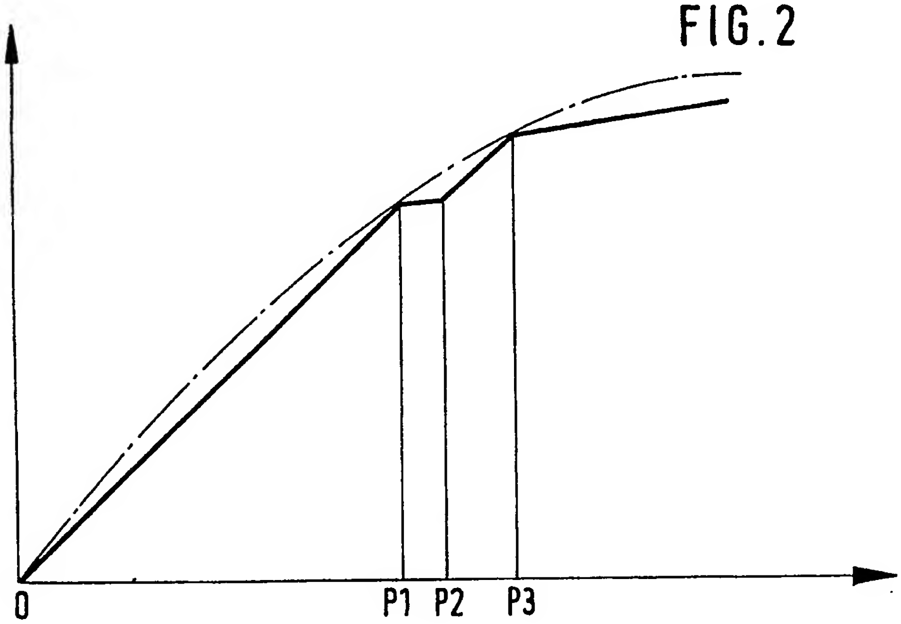

10
14
42
56
54
58
12
48
46
44
52
50
18
16
A30
A36
A38
20
34
30
36
32
22
40
38
24
26
28

FIG. 1

FIG. 2


0
P1
P2
P3

SPECIFICATION

A brake pressure regulator for an hydraulic vehicle braking system

The invention relates to a brake pressure regulator for an hydraulic vehicle braking system.

In a vehicle, the wheel brake cylinders of the front wheels can be directly connected to a main brake cylinder while the wheel brake cylinders of the rear wheels are connected to the main brake cylinder either together or separately via a brake pressure regulator. The function of the regulator is to reduce the increase in pressure during braking in the rear wheel brake cylinders from a particular switching pressure onwards in comparison to the increase in pressure in the main brake cylinder and in the front wheel brake cylinders such that locking of the rear wheels is avoided — which would otherwise have to be feared as a result of the forwards displacement of the vehicle weight during braking.

Known from patent specification No. 214279 B2 is a brake pressure regulator having a housing, inlet and outlet chambers defined in the housing, and a stepped piston received in the housing and having larger and smaller end faces acted upon by the pressures in the outlet and inlet chambers respectively. A valve controls communication between inlet and outlet chambers and is controlled by the stepped piston. An auxiliary piston is subjected to the pressure in the inlet chamber and a spring is confined between the two pistons to urge the stepped piston towards a first stop against the pressure in the outlet chamber and to urge the auxiliary piston towards a second stop against the pressure in the inlet chamber. A piston portion on the inlet side of the stepped piston is arranged concentrically within the auxiliary piston, and a powerful second spring acts between a fixed stop on the housing and the auxiliary piston. This second spring, in the same way as the first spring, biases the auxiliary piston towards the second stop against the pressure in the inlet chamber. When non-operative and during braking with minor pressure, both pistons remain in their end positions and the valve controlled by the stepped piston is open. The pressures in the inlet and outlet chambers are initially equal but if the pressure exceeds a particular switching pressure, the stepped piston is displaced in the direction towards the inlet chamber and the valve closes so that further rise in pressure in the inlet chamber is transferred to the outlet chamber not in full but only in a proportion dependent on the relative sizes of the two end faces of the stepped piston.

However, when a further, higher, switching pressure is reached in the inlet chamber, the auxiliary piston is displaced in the direction towards the outlet chamber and an inner annular shoulder formed on the auxiliary piston pushes against the end face of the stepped piston at the inlet end. From now on, the two pistons form a unit, with an operative end face at the inlet side which is equal to the sum of the end faces of both pistons. In the known brake pressure regulator, this sum is as large as, or larger than, the operative outlet-side end face of the stepped piston. As a result, the pressure in the outlet chamber, and thus in the connected rear wheel brakes, rises again from the second switching pressure onwards in the same predetermined proportion to the pressure in the inlet chamber and in the front wheel brakes.

A basis of the invention is the recognition that such rapid increase in pressure after the second switching pressure has been exceeded is not desirable for very long as the pressure curve as a whole is then only a very rough approximation to the ideal almost parabolic pressure rise in the rear-wheel brakes. It is therefore the aim of the invention to construct a brake pressure regulator such that it is possible for the pressure curve in the rear-wheel brakes to achieve a better approximation of the ideal rise in pressure.

According to the invention there is provided a brake pressure regulator for an hydraulic vehicle braking system, comprising a housing, an inlet chamber and an outlet chamber defined in the housing, a stepped piston accommodated in the housing and having a smaller face exposed to the pressure in the inlet chamber and a larger face exposed to the pressure in the outlet chamber, valve means controlling communication between the inlet and outlet chambers, the valve means being controlled by the stepped piston, an auxiliary piston subject to the pressure in the inlet chamber, the effective area between said larger and smaller faces of the stepped piston being greater than the effective face area of the auxiliary piston subject to the pressure in the inlet chamber, spring means acting between the stepped and auxiliary pistons for urging the stepped piston towards first stop means against the pressure in the outlet chamber, and for urging the auxiliary piston towards second stop means against the pressure in the inlet chamber, and third stop means on the housing for limiting movement of the auxiliary piston in the direction away from the second stop means, said third stop means not interfering with the freedom of movement of the stepped piston.

Under similar conditions, the brake pressure regulator according to the invention behaves in the same way as the known, genus-forming brake pressure regulator until the second switching pressure in the inlet chamber is exceeded and the auxiliary piston is displaced. In the brake pressure regulator according to the invention, however, the auxiliary piston is displaced only until it pushes against the third stop means on the housing. As a result, the auxiliary piston can only increase the force of the spring means to a value which is determined by the third stop means and which is reached at a third switching pressure in the inlet chamber.

The auxiliary piston of the brake pressure regulator according to the invention is never combined in a unit with the stepped piston and instead only acts on the stepped piston via the

spring means. The stepped piston therefore remains free to be displaced independently of the auxiliary piston in the direction towards the inlet chamber and is thus always able to close the valve means when the force of the brake fluid acting on the larger face on the outlet side is greater than the sum of the spring force and the force of the brake fluid acting on the smaller face of the stepped piston on the inlet side.

Thus, after the third switching pressure is exceeded, the rate of pressure increase in the outlet chamber again becomes less than in the range between the second and the third switching pressures. In this way a particularly good approximation of the ideal pressure curve can be achieved.

As in the known brake pressure regulator initially described above, the auxiliary piston in the brake pressure regulator according to the invention can have a cylindrical bore and slidingly receive a portion of the stepped piston at the inlet side. In a concentric arrangement of this kind, the operative outer diameter of the larger face of the stepped piston, in a preferred embodiment of the invention, is 10% to 20% larger than the operative outer diameter of the auxiliary piston.

In every case, the invention makes possible a particularly simple development of the brake pressure regulator in which the spring means acting between the two pistons provides the only spring loading the auxiliary piston.

A favourable curve of the rear-wheel brake pressure in relation to the front-wheel brake pressure similar to that achieved with the simply constructed brake pressure regulator according to the invention has up until now only been achievable in an hydraulic braking system (DE 1 292 023 C3) in which two pressure changing valves with different switching points and with straight characteristic portions are arranged in the pressure medium supply lines which lead from a main brake cylinder to pairs of wheel brake cylinders in the rear-wheel brakes.

An embodiment of the invention is described in detail below by way of example with reference to the accompanying drawings in which:—

Figure 1 is an axial section of a brake pressure regulator, and

Figure 2 is a graph showing the rear-wheel brake pressure (ordinate) over the front-wheel brake pressure (abscissa) in a vehicle braking system with a brake pressure regulator according to Figure 1.

The brake pressure regulator shown in Figure 1 comprises a housing 10 which is composed of a bell-shaped main portion 12 and a plug 14 screwed into said main portion 12. Both can be made of commercial rod steel with hexagonal profile.

The plug 14 has a threaded stud 16 which can be screwed directly into a main brake cylinder of normal construction (not shown). In the plug 14, an axial inlet canal 18 is formed which opens out into a likewise axial cylindrical inlet chamber 20.

In the main portion 12 of the housing 10, a spring chamber 22 is formed, adjacent to the plug 14 and connected with the surrounding atmosphere, for example by means of the fact that the screwed connection of the plug 14 with the main portion 12 is not sealed. Adjacent to the spring chamber 22 is a cylindrical outlet chamber 24 which is arranged coaxially with the inlet chamber 20, having a diameter which is approximately 15% greater than this. An outlet canal 26 leads from the outlet chamber 24 into a threaded bore 28; into this, can be screwed a pipe which leads to one or more rear-wheel brakes.

An auxiliary piston 30 is sealingly guided in the inlet chamber 20; this has a flange 32 extending into the spring chamber 22, and an axial cylinder bore 34. A piston portion 36 on the inlet side is sealingly guided in the cylinder bore 34 and, together with an outlet-side piston portion 38 sealingly guided in the outlet chamber 24, this forms a stepped piston 40.

The stepped piston 40 has a continuous axial canal 42 which expands inside the piston portion 38 on the outlet side and terminates at an annular valve seat 44. A closing body 46, guided so as to be axially movable in the piston portion 38 on the outlet side, is associated with the valve seat 44 and said closing body 46 is urged by a valve spring 48 in the direction of the valve seat 44. The closing body 46 is integral with a stem 50 which extends through the valve seat 44 and with which a stop 52 on the main portion 12 of the housing 10 is associated.

The stop 52 also limits the movement of the stepped piston 40 away from the inlet chamber 20. Between the piston portion 38 of the outlet side of the stepped piston 40 and the auxiliary piston 30, a spring 54 is biased such that in the shown inoperative position of the brake pressure regulator is presses against the stop 52 with a certain force and presses the auxiliary piston 30 with a force of the same intensity against a second stop 56 which is formed from the inner end face of the plug 14.

Movement of the auxiliary piston 30 in the direction of the outlet chamber 24 is limited by a third stop 58 formed on the main portion 12 of the housing 10 in such a manner that in any possible position of the built-in stepped piston 40 the auxiliary piston 30 cannot knock against the piston portion 38 of the outlet side of said stepped piston 40 or load the stepped piston 40 in any other manner than via the spring 54 with a force directed towards the outlet chamber 24, with the exception of minor frictional forces which can be transmitted via the sealing between the cylinder bore 34 of the auxiliary piston 30 and the piston portion 36 of the inlet side of the stepped piston 40.

The sizes of the end faces of the piston portions 36 and 38 on the inlet and outlet sides are A36 and A38 respectively; the operative end face on the inlet side of the auxiliary piston 30 is size (A30—A36), where (A38—A36) is larger than (A30—A36).

In Figure 2, the ideal pressure curve in the rear-

wheel brakes over the pressure in the front-wheel brakes is represented by a dotted line which is approximately parabolic. The actual pressure curve resulting on braking in the outlet chamber 24 and thus in the rear-wheel brakes, is represented by a straight line which deviates three times from its original straight course.

When the pressure in the inlet chamber 20, and thus in the front-wheel brakes, rises gradually from point 0 on braking, both pistons 30 and 40 remain for the time being in their inoperative position as shown in Figure 1. As a result, the valve constituted by valve seat 44 and closing body 46 remains open and, as long as this is so, the pressure in the outlet chamber 24 is always the same as in the inlet chamber 20. However, as soon as the pressure in these two chambers 20 and 24 reaches a point described as switching pressure P1, the resulting force

$$F1 = P1\ (A38—A36)$$

exerted by said pressure on the stepped piston 40 is as great as the bias of the spring 54 acting on the stepped piston 40 when the auxiliary piston 30 is in inoperative position.

Any further slight increase in pressure now has the effect that the stepped piston 40 is displaced away from the stop 52 against the force of the spring 54 so that the stem 50 can no longer prevent the valve spring 48 from pressing the closing body 46 against the valve seat 44. All further increase in pressure in the inlet chamber 20 is no longer transmitted in its full extent to the outlet chamber 24; additional brake fluid can now only reach the outlet chamber 24 due to the fact that the valve 44, 46 is alternately opened and closed by means of a rapid succession of slight to-and-fro movements of the stepped piston 40.

When the pressure in the inlet chamber 20 has again slightly increased and reached a point described as second switching pressure P2, it generates a force, which is greater than the force of the spring 54, on the operative end face A30—A36 on the inlet side of the auxiliary piston 30; as a result, the auxiliary piston 30 moves away from the stop 56. Thus, spring 54 is compressed so that the force it exerts on the stepped piston 40 becomes correspondingly greater while the rate of pressure rise in the outlet chamber 24 is correspondingly higher than in the stage between P1 and P2. On a third switching pressure, P3, in the inlet chamber 20, the flange 32 of the auxiliary piston 30 pushes against the third stop 58 fixed to the housing. From this moment on, the force of the spring 54 remains constant; as a result, the pressure in the outlet chamber 24 rises less steeply again as pressure in the inlet chamber further increases, as is shown in Figure 2.

CLAIMS

1. A brake pressure regulator for an hydraulic vehicle braking system, comprising a housing, an inlet chamber and an outlet chamber defined in the housing, a stepped piston accommodated in the housing and having a smaller face exposed to the pressure in the inlet chamber and a larger face exposed to the pressure in the outlet chamber, valve means controlling communication between the inlet and outlet chambers, the valve means being controlled by the stepped piston, an auxiliary piston subject to the pressure in the inlet chamber, the effective area between said larger and smaller faces of the stepped piston being greater than the effective face area of the auxiliary piston subject to the pressure in the inlet chamber, spring means acting between the stepped and auxiliary pistons for urging the stepped piston towards first stop means against the pressure in the outlet chamber, and for urging the auxiliary piston towards second stop means against the pressure in the inlet chamber, and third stop means on the housing for limiting movement of the auxiliary piston in the direction away from the second stop means, said third stop means not interfering with the freedom of movement of the stepped piston.

2. A brake pressure regulator as claimed in claim 1, wherein the auxiliary piston has a cylindrical bore and slidingly receives a portion of the stepped piston, said larger face of the stepped piston having an operative outer diameter 10% to 20% larger than the operative outer diameter of the auxiliary piston.

3. The brake pressure regulator as claimed in claim 1 or 2, wherein the spring means acting between the stepped and auxiliary pistons provides the only spring loading on the auxiliary piston.

4. A brake pressure regulator substantially as herein described with reference to the accompanying drawing.

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